DACA42- 03-C-0060

LOGANEnergy

Yosemite National Park PEM Demonstration Program, Final Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement
Energy Conservation Demonstration CERL 15

Headquarters:

1080 Holcomb Bridge Rd
Suite 100-175
Roswell, GA 30076
Ph (770) 650-6388

Administrative Building,
Yosemite Valley
Yosemite National Park

November 29, 2005

California:

5680 Adobe Rd
29 Palms, CA 92277
Ph (760) 367-5005

Executive Summary

On July 21, 2003 LOGANEnergy Corporation received a contract issued by ERDC/CERL to purchase two LPG 5kW PEM fuel cells for Yosemite National Park, install one at the National Park Service administration building and provide one year of service and maintenance for the installed unit. The second unit was place in storage at the Park Service High Voltage Shop in El Portal, CA until the Park Service determined where to install it, and when they could assign their electricians to do so. Funding for this project was provided through the cooperative efforts of DOE Bonneville Power Authority and USACERL. The project kick-off meeting occurred on September 3, 2003. A list of the attendees may be seen in Appendix 1. The meeting focused on specific issues and concerns expressed by the Park Service regarding the placement of the fuel cell unit, public safety, job site security, conformity with historic character of the administrative center, and sensitivity to archaeological findings during installation. The project began in October 2003, but due to logistical delays with equipment deliveries, communications service delays, and commissioning delays due to equipment malfunctioning, the fuel cell did not complete a successful acceptance test until mid May 2004. However, it was not until mid July 2004 that a number of restraining power plant performance and operating issues were resolved to a point that the unit could be considered operational.

The Park Service Combined Heat and Power (CHP) fuel cell installation supplies 110-120VAC service to the facility's electric loads in a grid parallel/synchronous operating configuration. The facility's hot water boiler captures the fuel cell's thermal capacity through a new heat exchanger installed for that purpose. The installation is instrumented with an external wattmeter, BTU meter, and a gas flow meter. A phone line is connected to the power plant communication's modem to call-out with alarms or events requiring service and attention. In addition, this site has a web-enabled SCADA system that provides real time operational control, management and alarming.

The Point of Contact for this project is Kent Summers. He may be reached at (209) 770-5201, and email Kent_Summers@nps.gov

The total energy cost premium to the host site as a result in participating in this demonstration project was $1892.16

Table of Contents

Update Table of Contents

Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

Yosemite National Park Administration Building, Yosemite Valley, CA

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 PAFC and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 8 new projects in the US and the UK over the next 12 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P LP Gas unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vincent Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1338, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Contract: Four-year PC25 PM Services Maintenance Agreement.
In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Scott Wilshire.

968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1338

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work. The units are located at residential sites at Patuxant River Naval Air Station, MD and operate in standard gird connected/grid independent configurations.

c) Contract: A Partners LLC; Commercial PC25 Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C CHP fuel cell installation in Fresno, CA. The CHP system operating configurations allow for both grid parallel and grid independent energy service and up to 1.5MMBtu/H of thermal energy for HVAC loads in the facility.

7.0 Host Facility Information

Yosemite National Park was established on October 1, 1890, and is the Nation's third oldest national park. The park was established to preserve the resources that contribute to its uniqueness and attractiveness. Congress recognized the importance of preserving this great park for future public enjoyment when it established Yosemite National Park. Yosemite National Park is a showcase of spectacular geological features, including the greatest concentration of granite domes in the world and the largest exposed granite monolith in the world.

The first application of a park concept originated in Yosemite with the grant of 1864 (Federal land given to California for preservation) signed by Abraham Lincoln and since that time the park has played an important role in pioneering park management concepts.

Yosemite National Park possesses outstanding recreational values and supreme scenic attractions, including alpine and sub-alpine wilderness, three groves of giant sequoia trees, and thundering waterfalls that are among the world's highest. Yosemite was the birthplace of the idea of the Sierra Club and plays an important role in the preservation of wildlife and biological diversity.

Yosemite National Park is a world heritage site, which has made a significant contribution to California's cultural heritage, to the national park movement, and to Yosemite's 4,000 years of cultural heritage by Native Americans. The park provides solitude and inspiration and serves as an outdoor classroom for environmental education.

8.0 Fuel Cell Installation

Yosemite officials selected the National Park Service administration building in Yosemite Valley as the host site for the project. The fuel cell product selected for the project was the Plug Power GenSys 5P 4.5-kilowatt LP Gas fuel cell power plant. This site was the third to have a Plug Power LP Gas unit. The unit operates nominally at 2.5 kW and consumes .53 gallons per hour of LP Gas. At this rate the unit achieves only 20% electrical efficiency, which is very low as compared to more conventional means of power generation. However, this project was ideally sited in an area of environmental extremes that challenged its reliability and readiness for remote off-grid applications that represent near term commercial applications. In those situations, the trade for reliable power will be low electrical efficiency and high power costs until product improvements occur. Yosemite Valley's power provider is Pacific Gas and Electric Company, and Camphora, a local LP Gas company, provided gas service to the fuel cell installation.

Photo (1) below shows the fuel cell on its pad adjacent to the entrance to the Park Service administration building, seen in the background. The fence behind the fuel cell encloses a diesel generator and fuel storage tank. Note the exterior shingle wall construction of the fence. This is an example of the historical accuracy that LOGAN had to replicate with the fuel cell fence, clearly seen in photo (6) below, in order to have it approved by the Park Service. The shingles on the new fence are cut from Sierra Sweet Pine trees, and were a special order from a local vendor.

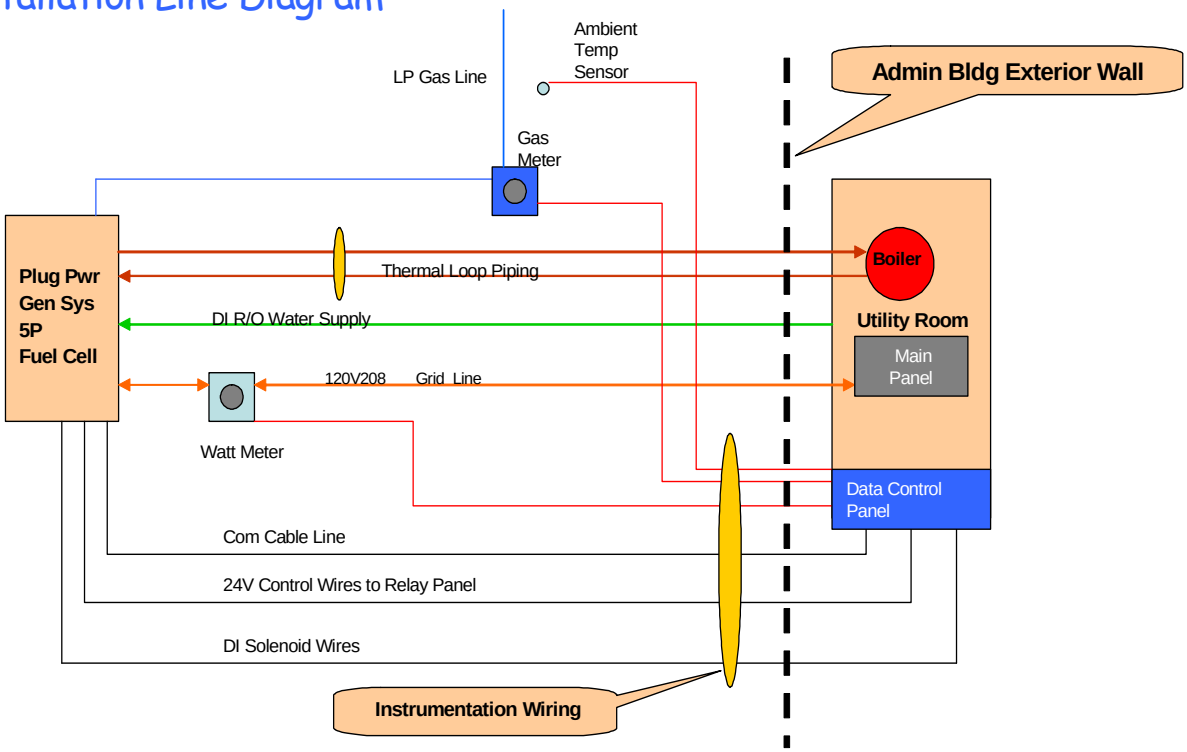
Photo (2) below shows the exterior wall with a window that provides light to the mechanical room in the basement below grade. Conduit and piping runs connecting the fuel cell to electrical and mechanical interfaces had to penetrate this 12-inch granite wall just below the window.
Photo (3) below shows the LP Gas supply line routing from the foot of the pad site to LP Gas tank farm. The route passed just inside the bollards that line the parking lot.
Photo (4) below depicts the same routing from the tank farm back to the fuel cell pad site. During excavation and construction of this fuel line, a Park Service Archaeologist and a Tribal Observer examined excavations and many soil samples for evidence of historic artifacts. No materials of historic significance were encountered.
Photos (5) and (6) below are shots of the site as constructed. A protective tarp covers the fuel cell in photo (5).
In order to proceed with construction, LOGAN secured a Digging and Archaeological permit and a Safety Permit from the Park Service. LOGAN applied for and received a received an air quality permit wavier from Mariposa County Air Pollution Control District. Since the Park Service owns the transmission and distribution wires within Yosemite, the project did not need a grid connection permit.

Prior to commencing the installation tasks, LOGAN complied with the preliminary requirements previously described in the executive summary. These issues were resolved to the Park's satisfaction during August and September 2003, and by early October site work began. During October the project reached 90% completion, however, further progress halted until February 2004 due to a delay in receiving a new 1000-gallon LP Gas fuel storage tank for the project. This tank was furnished under terms of a project cost-sharing grant provided by the Propane Educational Research Council (PERC) and procurement was not possible until the grant reached the Park Service. LOGAN completed the fuel cell installation in mid February, but the Park Service would not grant permission to start the unit without first installing a screening fence around the fuel cell site. After lengthy discussion concerning both the design of the fence and the appropriate materials that would be used in its construction, LOGAN completed that task on March 30, 2003 and attempted the first fuel cell start on the same day. The actual start leading to an acceptance test did not occur, however, until mid May after correcting a number of electrical and software issues. Work logs describing the several months of installation and service activities may be viewed in the Appendix section found at the end of this report.

9.0 Electrical System

The Plug Power GenSys 5P fuel cell inverter has a power output of 110/120 VAC at 60 Hz. At this site the unit operated continuously at 2.5kW, providing power to three-phase 208 VAC circuits. In order to match the building's three-phase distribution, the fuel cell was wired to a new grid parallel/synchronous 50-amp circuit breaker in the service panel pictured to the right. It powered one phase of the three-phase circuit with approximately 30 amps service. The line diagram pictured below provides an illustration of the electrical configuration, as well as the overall installation scheme.

Yosemite Fuel Cell
Installation Line Diagram

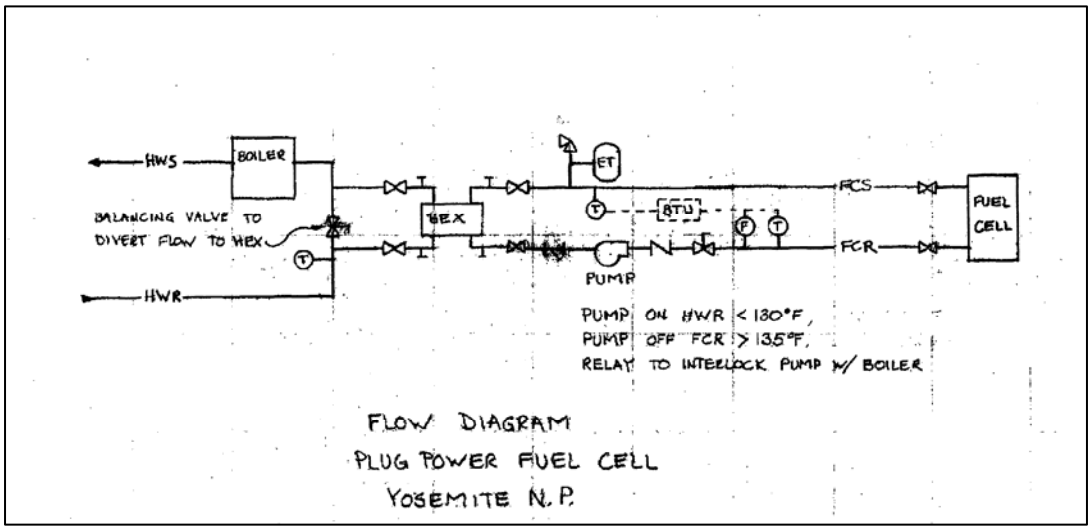


10.0 Thermal Recovery System

Pictured at right is the hot water boiler that is located in the basement of the Park Service administrative building. The boiler supplies hot water to coils in the building's winter heating system. The Plug Power GenSys5P internal heat exchanger provides approximately 7,800 Btu/H thermal energy at 140 degrees F. In order to capture this heat, LOGAN installed hot water supply and return piping from the fuel cell customer interface to a new shell and tube heat exchanger integrated into the boiler feed water piping. The purpose of the installation was to preheat the boiler feed water in order to reduce its demand for source fuel. Since the boiler's use is limited to seasonal space heating, there is no thermal recovery data at this point in the project.

A simple schematic of this installation can be viewed in the one-line drawing below. The

diagram illustrates the location of thermal RTDs, flow meter, expansion tank, circulating pump, and valves all necessary to control and measure heat transfer to the facility. The circulating pump control relay turned on the pump when two conditions were satisfied, (a) the boiler return water temperature was less than 130 degrees F, and (b) the fuel cell return water temperature was greater than 135 degrees F.



11.0 Data Acquisition System

Over the last two years in the course of developing numerous small-scale PEM fuel cell sites, LOGAN has learned the value and importance of Web based, real-time communications to manage distributed resources. With growing numbers of fuel cell units operating at diverse locations across the US, this capability introduces a cost effective means of supporting the fleet and capturing data that is necessary to manage systems and evaluate performance. As an example, the primary service respondent for this project had to travel approximately 8 hours to reach the Yosemite fuel cell site. These trips are mostly routine in nature and necessary to service and maintain the fuel cell installation or to download performance data. With the advent of real-time communications, streaming data is continuously stored at a central hub and is constantly available for retrieval and analysis. The communications package also provides the operator with functional screens that are management tools displaying system status and performance, operational trending, system alarming and service callouts. Having access to this information permits the distributed generation operator to support more units over a wider area with fewer service personnel than would otherwise be possible. In many cases, today, troubleshooting an alarm or system turndown may be performed from a computer terminal. With the next generation system, it will be possible to make remote corrective inputs to the system to prevent a shutdown or at least dispatch service confidently with the parts necessary to quickly turn the unit around.

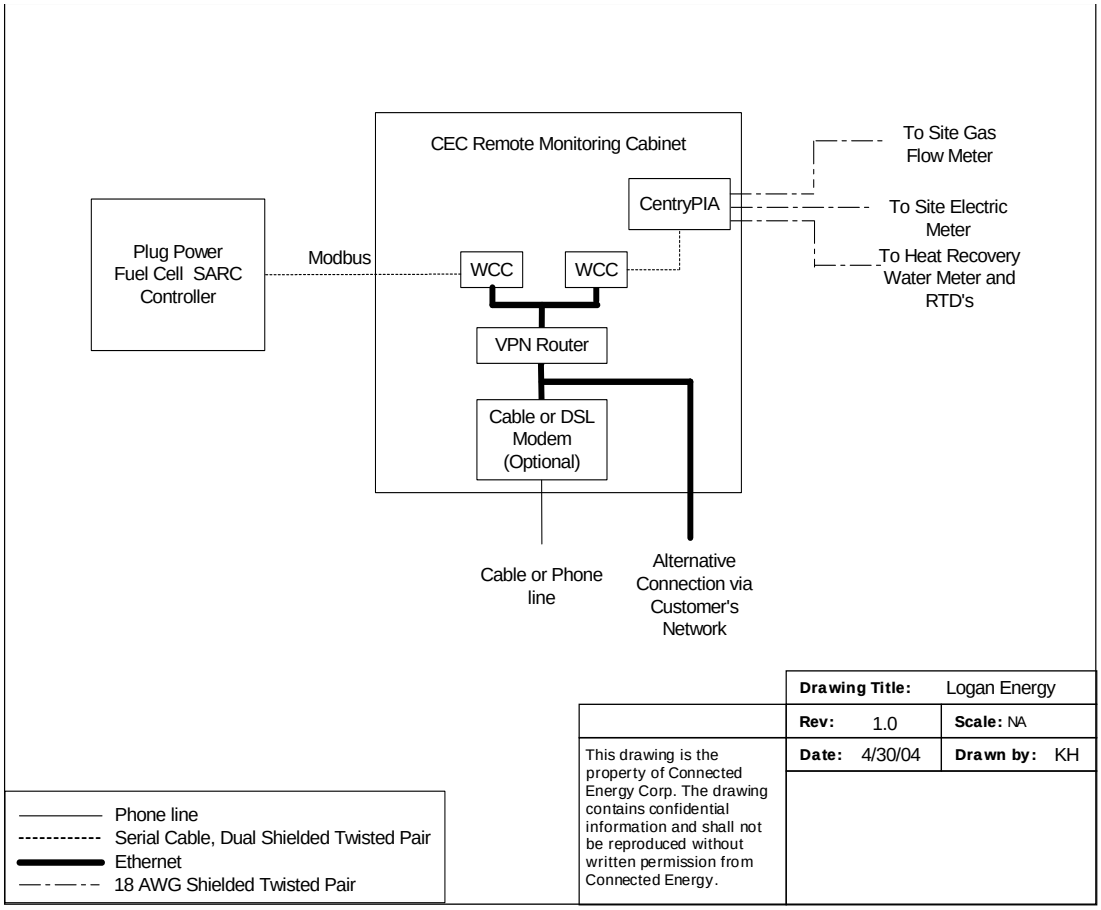
With the introduction of this communications package to the Yosemite PEM demonstration project, LOGAN's education in Web based communications installation and management continued to expand. Typically, a cable service provider or a high speed DSL Telephone Company provides the service connection for the Web communications package. The service available in Yosemite Valley is the DSL variant provided by Pacific Bell. LOGAN placed the

service order for this project in January 2004, but DSL was new to the valley and demand high, so it was not available to the site until mid March. In mid April the communications package became operational.

Pictured directly below is schematic drawing of the web communications package architecture and below that an example of one of many data screens that are maintained by the Connected Energy package that provides the operator with a quick indication of system status. To view the operation of this unit, log on to https://www.enerview.com/EnerView/login.asp
Then login as: logan.user and enter password: guest. Select the box labeled National Park Service, or go to other LOGAN sites using the tool bars or html keys.

The Appendix section of this report contains two charts detailing the performance of the Yosemite fuel cell since its initial start.

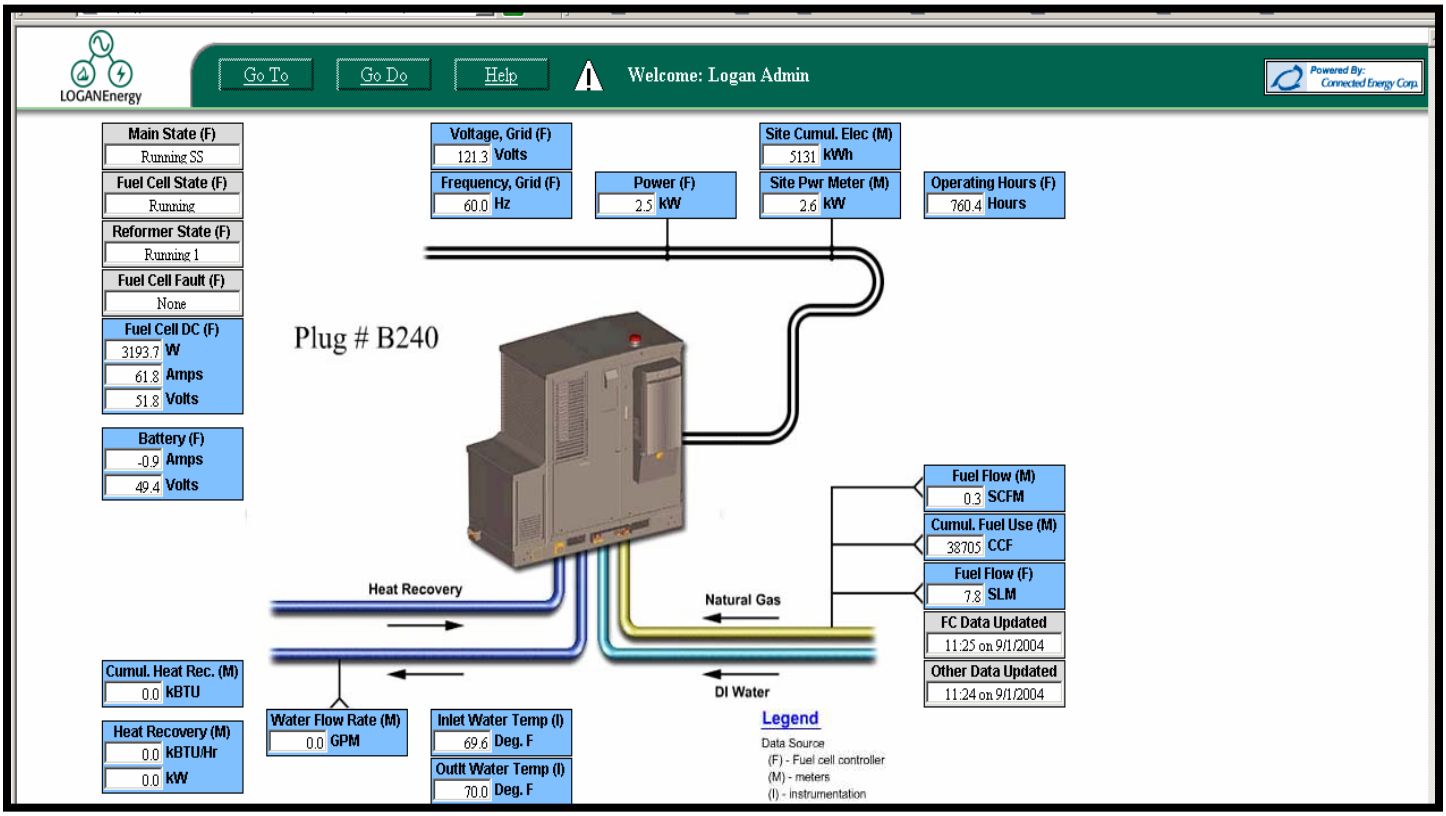
Connected Energy Web Communications System Architecture



Connected Energy Web Data Screen

By viewing this screen, the operator may quickly determine that the power plant is running without any faults; that it is producing 2.5 kW from 51.8 volts DC cell stack output; its fuel flow is 3000

SCFM; there is no heat transfer taking place between the unit and the heat exchanger at the boiler; and that the system updated the screen at 11:25 on September 1, 2004.



12.0 Fuel Supply System

Fuel supply to the Yosemite PEM unit began with a 1000 gallon LP Gas storage tank located 300 feet west the fuel cell pad. Before entering the fuel cell inlet, the gas flows through a flow meter, which sends a flow signal to a terminal in the Web package RTU to capture and store flow data. Then a pressure regulator reduces the line pressure to 14 IWC before entering the “gas

box" section of the reformer. HD-5 LPGas is the propane variant required by the manufacturer for this product because it is rated with the highest percent propane content from among the several categories of LPGas. While operating at a set-point of 2.5 kW the Plug unit consumed 5.3 gallons LPGas per hour. At that rate, the gas storage tank needed refilling every 2 months. The photos below picture several stages of LPGas fuel line construction.

13.0 Program Costs

Yosemite National Park PEM Demonstration Program

Project Utility Rates		**Providers**
1) Water (per 1,000 gallons)	$ 1.25	Valley Water
2) Utility (per KWH)	$ 0.170	PG&E
3) LP Gas (per gal)	$ 1.25	Camphora Gas

First Cost	**Budgeted**	**Actual**	**Variance**
Plug Power 5 kW GenSys5P	$ 75,000	$ 75,000	**$ -**
Shipping	$ 2,400	$ 2,400	**$ -**
Installation Electrical	$ 9,000	$ 14,820	**$ 5,820**
Installation Mechanical/ LP Gas Line	$ 22,330	$ 22,507	**$ 177**
Installation Thermal	$ 21,197	$ 38,112	**$ 16,915**
Web Communication Package	$ 3,015	$ 11,250	**$ 8,235**
Archaeology/ Tribal Observer	$ 8,000	$ 2,909	**$ (5,091)**
Site Prep, Labor Materials, Fence	$ 5,550	$ 4,535	**$ (1,015)**
Training	$ 3,600	$ 3,600	**$ -**
Technical Supervision/Start-up	$ 9,720	$ 9,720	**$ -**
Decommissioning Site Restoration/Hrs	$ -	$ -	$ -
Total	**$ 159,812**	**$ 184,853**	**$ 25,041**
Assume Five Year Simple Payback	$ 32,750	$ 38,420	**$ 5,670**

Annual Technical Services	**Budgeted**	**Actual**	**$/Hr**	**Budgeted**	**Actual**	**Variance**
Technical Services Maintenance/Hrs.	500	625	$ 94	$ 47,000	$ 58,750	$ 11,750
Report Writing/Hrs	94	94	$ 100	$ 9,400	$ 9,400	$ -
Travel Costs		0		$ 22,375	$ 15,358	$ (7,017)
Mgmt Performance Monitoring/Hrs.	275	275	$ 100	$ 27,500	$ 27,500	$ -
Total Services	**869**	**994**		**$ 106,275**	**$ 111,008**	**$ 4,733**
Total Project & G+A				**$ 266,087**	**$ 295,861**	**$ 29,774**

Annual Operating Expenses	**Budgeted**	**Actual**	**$/Hr**	**Budgeted**	**Actual**	**Variance**
LP Gas as GPH @ 2.5 kW	0.5300	0.5300	$ 0.663	$ 5,223	$ 5,223	$ -
Water Gallons per Year	14,016	14016		$ 18	$ 18	$ (0)

Economic Summary	**Budgeted**	**Actual**	**Variance**
Forecast Annual kWH	19710	19710	0
Annual Cost of Operating Power Plant kWH	$ 0.2660	$ 0.2660	$ -
Credit Annual Thermal Recovery kWH	$ (0.1220)	$ -	$ 0.1220
Project Net Operating Cost kWH	$ 0.1440	$ 0.2660	$ 0.1220
Displaced Utility cost kWH	$ 0.1700	$ 0.1700	$ -
Energy Savings (Increase)	$0.026	($0.096)	$ (0.1220)
Annual Energy Savings (Increase)	$512.46	($1,892.16)	$ (2,404.62)

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed *actual* first cost components.
Assumed Five Year Simple Payback is the First Cost Total *divided by* 5 years.

Forecast Operating Expenses:

LP Gas usage in a fuel cell system set at 2.5 kW will consume 0.53 gph. The cost per hour is 0.53 gph *x* the cost of LPGas/gallon. The cost per year of $ 5223.44 equals the product of cost per hour ($0.66) *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

LPGas fuel cell systems set at 2.5 kW output will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed of 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year at $17.52 equals 14,016 gph *x* cost of water to the site of $1.25 per 1000 gallons.

The Total Annual Operating Cost, $5240.67 is the *sum of* the cost per year for LPGas and the cost per year for the water consumption.

Economic Summary:

The Forecast Annual kWh at 19,710 kWh is the product of 2.5 kW set point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

The Annual Cost of Operating the Power Plant at $0.266 per kWH is the Total Annual Operating Cost at $5240.67 *divided by* the forecast annual kWh at 19,710 kWh.

The Credit Actual Annual Thermal Recovery is $0.0.

The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.

The Displaced Utility Cost is the cost of electricity paid by the National Park Service to PGE.

Energy Savings (Cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost expressed in kW.

Annual Energy Savings (Cost) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Milestones/Improvements

System Commissioning Observations:

Although the Yosemite unit completed a successful 8-hour customer acceptance test on May 12 2004, this occurred after one month of troubleshooting various system hardware and software issues. After the acceptance test the unit continued to operate at very low availability rates for the next two months requiring extensive troubleshooting and service before it could be considered “in service”. This is a recurring issue at most sites that mitigates in favor of establishing a “shake down” performance tuning period for the power plant before commencing its period of performance that seeks to establish 90% availability. The event logs in the Appendix below detail the Yosemite “shake down” issues that required several weeks of intense service support to optimize system performance. Apart from having to replace a bad inverter right out of the box, troubleshoot recurring nuisance trips, and working through stuck valves and clogged filters, one particular event serves as a reminder that these units are still beta test systems. On June 16, while attempting to restart the power plant, the unit experienced a muffled “cook-off” or backfire through the exhaust stack. The event caused sufficient concern to warrant powering it down and suspending operations until the problem could be determined. The unit remained in that state for the next week while Plug analyzed the data. On June 23 LOGAN returned to the site to begin a series of test procedures informed by Plug’s event analysis. Filters were changed, software reloaded and the system was checked for gas leaks. An attempted restart failed. On June 30 LOGAN’s engineer returned to the site to replace the air/gas blower but the part arrived without gaskets, so the job was halted. On July 6, the field engineer returned to the site with the blower gaskets and completed the repairs. Following that the unit started successfully and has operated normally since then.

If the "out of the box" performance of PEM program beta units performed more like commercial product, then the project period of performance could begin immediately. Since that is not so, the period of performance should be adjusted to allow project operators to conduct at least six weeks of post-start tuning and performance optimization before the project begins in earnest

15.0 Decommissioning/Removal/Site Restoration

At this date LOGAN is awaiting for the park service to provide guidance on the removal and restoration of the site. This will be accomplished as soon as possible given the accessibility of the site during the winter months.

16.0 Additional Research/Analysis

An important lesson that grew out of the Yosemite project dealt with developing greater understanding regarding the reliability and functionality of web based SCADA communications. After installing the components seen in the block diagram on page 13 LOGAN quickly realized that system functionality was more difficult to achieve than "plug and play". For example, the quality and reliability of individual sensors that create and send output signals to terminals at the web router interface are critical to optimum performance. In addition, the gas meters, watt meters, flow meters and thermal elements invariably require signal strength adjustment at the RTU terminals to insure that their discrete inputs are readable by the CEC system. Discovering the proper voltage range required for each signal loop is most often achieved by trial and error, requiring multiple site visits to establish a readable connection. In other instances LOGAN has discovered that flow metering devises and thermal couples often require high levels of maintenance and/or replacement to support continuous data collection. Heretofore LOGAN has purchased comparatively inexpensive components to meet these requirements, but has learned the value of installing robust and durable commercial grade components that cost more to install but provide higher reliability.

17.0 Conclusions/Summary

After 8 years of supporting many fuel cell installations at various locations throughout the US, the Yosemite project was easily the most distant from a LOGAN service center. The travel time to the site took approximately 10 hours during good weather conditions. During the winter months the travel time could take twice as long particularly if the technician encountered weather delays that made the site inaccessible. Spare parts supply often encountered weather delays sometimes completely missing the technician's availability at the site.

Yosemite was also LOGAN's first experience in fielding and supporting an immature LPGas fuel cell product. This combination of engaging a remote site and LOGAN's inexperience with the product exacerbated routine service issues into more complex ones. For these reasons the Yosemite PEM demonstration project proved to be far more challenging and difficult than LOGAN anticipated. Start-up and commissioning of the site were unusually challenging because of the "beta" status of the product, its poor "out of the box" performance, and because of the repeated "call-backs" required to deal with numerous product deficiencies highlighted in the paragraphs above.

Notwithstanding these difficulties, the project provided an excellent training exercise to enhance technical skills and improved the knowledge base of the attending field engineers. The project also forced needed changes within LOGAN's service organization to be able to respond to remote sites with the same thoroughness as those nearby. As a result, this site contributed to the rapid expansion the company's fuel cell knowledge base and confidence, but similarly it has contributed valuable data to the PEM Program and to Plug Power engineering as well.

In addition to being LOGAN's first LPGas installation, there were other firsts as well. This was the first fuel cell installation at a national park which required special attention to environmental, historical, and Native American cultural concerns. The Yosemite project was LOGAN's first to engage an archaeologist as well as a Native American tribal leader to monitor the site and the disturbance of all ground material to insure it did not contain historically significant artifacts. This added additional installation cost and delay at the site since LOGAN had to work within the park service guidelines governing the historic nature of the site. Even the fencing shingles seen in the photo on page nine above had to conform to the historical specifications maintained by the park. In dealing with these difficult issues, LOGAN received the generous support and help of Kent Summers, the parks project engineer and inspiration for the project.

In general terms, the Yosemite project did not encounter any major obstacles or other events that patience and cooperation among the stakeholders did not eventually solve. However, gaining access to commercial ISP service in order to activate the Web SCADA system was a difficult and time consuming issue that has proved endemic to most PEM demonstration projects. In this case, the remote location and the restricted availability of high-speed DSL lines delayed the availability of performance data for the first three months of the project. Even so the loss of data and operating availability during the initial period was overcome by extending the period of performance to 17 months. The test period concluded with a total 12,963 fuel cell load hours, 22,953kWh and achieved overall availability of 91%.

Though the project budget approved by CERL amounted to $350,000 for the purchase of two Plug Power units, the complete installation of one of the units and the commissioning, only, of the second, the actual funds available to the demonstration project were $267,500. LOGAN provided an additional $30,000 in cost share due to the necessity of operating the unit for 17 months to bring the project to a successful completion. Much of the additional cost may be attributed to unbudgeted hours spent working through issues related to the Web communications/fuel cell interface, and learning how to properly support and maintain an LPGas system. Though Plug Power provided good support, and learning much of this was accomplished through trial and error with the testing/replacement of various components and learning how to support such a remote site with limited resources.

In summary, the lesson learned at this site will have positive implications for future PEM operations and customer services. As these experiences are transferred to future installations they will directly benefit the community of CERL projects and equally enhance the reliability of future Plug Power products. The project elevated the awareness of fuel cell technology at Yosemite, educated the stakeholders, and advanced the broader objectives of the fuel cell industry and product commercialization.

Appendix

1) Maintenance Logs
2) Monthly Performance Data
3) Performance Charts

1. Maintenance Logs

LOGANEnergy Corp.

Monthly Site Report

Period October-04

Site Yosemite

Engineer	Date	PP S/N	Summary/Milestones
G Collard	10-12-14-03	240	Commenced project installation with mobilization. Briefed Champion Mechanical on job with Mike and Dan. Flagged LPG fueline back to tank, met with archaeological director to review recovery requirements. Located telephone and electrical connections. Discussed project safety plan with park service safety inspector.
	10/16/2003		Began trenching propane fuel line. Set fuel cell pad and delivered fuel cell to site. Fuel Cell roof panel damaged in shipment and advised Plug Power that it would need to be replaced. Worked on mechanical installation in boiler room with Champion.
	10/17/2003		Good progress on trenching propane line from tank to fuel cell pad. Ran telephone conduit from hub to fuel cell. Departed site
	10/28/2003		Completed installation of the propane fuel line to fuel cell pad and pressure tested good. Archaeologist completed his work without discovering any historic materials that might cause further delay. Started installing conduit and piping runs from the fuel cell to the mechanical room. Propane delivery may become an issue because Kent is awaiting on a grant from PERC to cover cost of new tank and a year of propane gas for the project.

Engineer	Date	PP S/N	Summary/Milestones
G Collard	11/1/2003	240	Installation halted pending delivery of propane tank.

Engineer	Date	PP S/N	Summary/Milestones
G Collard	12/1/2003	240	Installation halted pending delivery of propane tank. Started discussion with local phone company to provide a high speed connectin to the fuel cell site.

Engineer	Date	PP S/N	Summary /Milestones
G Collard	1/1/2004	240	Installation halted pending installation date for propane tank.

Engineer	Date	PP S/N	Summary/Milestones
G Collard	2/8/04	240	Travel to Yosemite
G Collard	2/9/04	240	Continue Installation
G Collard	2/10/04	240	Continue installation, Champion mechanical on board.
G Collard	2/11/04	240	Continue installation. System filling.
G Collard	2/12/04	240	Completed installation including propane. Will attempt start in the morning.
G Collard	2/13/04	240	Attempted start. Had to leave at noon due to storm.
G Collard	2/13/04	240	Drive back to Twenty-nine Palms

Engineer	Date	PP S/N	Summary/Milestones
G Collard	4/1/04	240	Worked with Jeff and Mark of Connected Energy to connect to the box. It seems that we need a crossover cable in order to work with the DSL box. We will pick up a cable and install it next Thursday when we come up for the media event.
	4/5/04		System Status: Running Maintenance: Battery is floating at 51 VDC, need to load battery charging setpoints. DO NOT use the file currently on the 1.10.1 CD, C. Ashley will provide the .rom file.
	4/8/04		System Status: Running Maintenance: Battery is floating at 51 VDC, need to load battery charging setpoints. DO NOT use the file currently on the 1.10.1 CD, C. Ashley will provide the .rom file (sent via email on 4/5).
K Williams	4/13/04	240	Another lesson in the "you don't want to shutdown a running fuel cell" book. Yosemite was running fine but we had the time to install the new inverter setpoints and do the rest of the TSBs but we could not restart it. We couldn't get the Sarc to power up.
K Williams	4/14/04	240	Drove to Yosemite and trouble shot the problems with the the heat recovery loop and Connected Energy Box. We got all portions of the Connected Energy box working except the flow meter. Fuel Cell needs new batteries. Chris is sending some out.
	4/14/04	240	Drove back to Fresno
G Collard	4/16/04	240	Drove to Yosemite Continued trouble shooting the heat recovery loop. There ended up being an air lock in the loop. We had to disassemble a portion of the loop in order to get it cleared. We replaced the circulating pump which is probably good. Left t
G Collard	4/17/04	240	Checked on Fuel Cell and Connected Energy data. Screen not available on line yet.
G Collard	4/18/04	240	Drive back to Fresno

Engineer	Date	PP S/N	Summary/Milestones
G Collard	3/5/04		Installed waiting DSL hook up scheduled for 3/8/2004 Drove to Fresno and picked up Melissa White. We drove on up to Yosemite and showed Melissa the sites and then on to dinner.
	3/8/04		Drove to Yosemite and briefed Melissa on the installation. Met with Kent Summers and Craig Struble on the fence issue. Got the fence locked down to where we can install it and start the fuel cell. We then drove back to Fresno and gave Melissa a tour of
	3/9/04		Discussed the overall PEM program with Melissa and took her to the airport.
	3/10/04		System Status: Installed – waiting phone line installation before commissioning.
	3/15/04		**Perform heat exchanger pressure test per TSB-0103 prior to startup.** I spoke to George Collard, he is verifying that he has the proper materials to perform this test.
	3/17/04		Michael, Jerry and I drove to Yosemite and set poles for fence around the fuel cell.
	3/18/04		Started to construct the fence.
	3/19/04		Completed the fence around the Fuel cell. The telephone line is landed and active. The line has also been tested for DSL. It works fine
	3/20/04		Drove to 29 Palms.
Collard	3/30/04	240	Completed painting fence, Started fuel cell. Fuel cell is running at 2.8 kW. We are working on the connected energy box. Need to get the DSL connection registered. We should get that done tomorrow.

K Williams	4/18/04		Sunday at Yosemite
	4/20/04		System Status: Shutdown Incident Description: System was manually shutdown to update battery charging setpoints and perform outstanding TSB's. Upon restart batteries were found to be dead. 4 batteries were ordered for delivery on 4/16. Maintenance: Battery is floating at 51 VDC, need to load battery charging setpoints. DO NOT use the file currently on the 1.10.1 CD, C. Ashley will provide the .rom file (sent via email on 4/5).
	4/21/04		Worked with Mike A. on Connected Energy equipment
	4/21/04		System Status: Shutdown Incident Description: System was manually shutdown to update battery-charging setpoints and perform outstanding TSB's. Upon restart batteries were found to be dead. 4 batteries were ordered for delivery on 4/16. George and Keith replaced batteries on Frid
	4/22/04		System Status: **Shutdown** Incident Description: System called in this morning. It shut down yesterday for TIMEOUT_LOSS_OF_GRID, Error Code: (416) @ 11:44 AM.
G Collard	4/28/04	240	Drive to Yosemite from Fresno. Troubleshoot the Grid circuit breaker tripping. No problems found in the wiring. It was decided that we would change the grid power breaker in the panel to a larger one. Ordered new breaker. Drive back to Fresno.

Engineer	Date	PP S/N	Activity
G Collard	5/4/04	B240	System Status: **Shutdown** Incident Description: Breaker in main service panel is tripping preventing connection with grid. Incident Resolution: New breaker is being installed to handle high in-rush current. ALARM: Fuel Cell B240 Shutdown ALARM TIME: 5/4/2004 1:10:08 PM UTC EQUIPMENT: SITE: Yosemite Ranger Station
G Collard	5/4/04	B240	Got to the site and the Circuit breaker had not tripped since we left last. Shut the power off and installed a 70 amp breaker. Turned power back on. Checked batteries and they were down to 43.4 volts. We put the 48 volt charger on and went for a start. The fuel cell did not trip the breaker during start this time around. We had the charger on the batteries this time but we did not last time we started. Once we got running, we took the charger off the batteries. Shortly after doing this the fuel cell started tripping the breaker again. We would reset it and it would trip again in about four to five minutes. We talked with Plug, sent the data and then shut the unit down. We buttoned it up and headed for Sierra Army Depot. If Plug comes up with a suggestion then we will return home via Yosemite and take care of it.
G Collard	05/06/04	B240	Chris had us download data from the inverter. Data showed the inverter bad. Plug is shiping out a new inverter. Drive to Fresno.
	05/07/04	B240	System Status: **Shutdown** Incident Description: Breaker in main service panel is tripping preventing connection with grid. Incident Resolution: 70-amp breaker was installed but did not solve the problem. Mike A noticed that a contactor was clicking on and off inside the inverter and that the Inverter tab of the Service Interface was indicating a Hardware fault condition. Usi
G Collard	05/10/04	B240	Travel to Fresno.
G Collard	05/11/04	B240	Traveled from Fresno to Yosemite. Turned off the power and disconnected the batteries. Removed the inverter and installed the new one. No significant problems. Once we had the inverter in we charged the batteries. They were down to 34.24VDC. Started the fuel cell and it came right on line. Fuel cell is running well at this point. Grid circuit breaker is no longer tripping. Travel back to Fresno.Traveled from Fresno to Yosemite.
	Failure Date		04/22/04
	Restart Date		05/11/04
	Hrs. Unavail		456.00
	Describe Problem		Fuel Cell was tripping the Grid Connect circuit breaker. Replacing the inverter corrected the problem.
	5/14/2004		System Status: **Unknown** Incident Description: Breaker in main service panel is tripping preventing connection with grid. A non-resetable Hardware fault was detected that indicates the inverter needs replacement. Incident Resolution: Inverter replacement was scheduled for 5/11. No call-in data has been received at Plug Power since 4/22. I will try to dial the system later today to verify status.
	5/18/2004		System Status: Running I called the system on Friday (5/14) and it was running. I set up data logging, the system called in on Saturday and Sunday with a full data set. Call in time is set to 7:45 PM EST so the data at Plug Power is always 2 days behind during business hours. I

Engineer	Date	PP S/N	Summary/Milestones
M Altemoos	6/9/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: I noticed that the system was running with a low S/C ratio, SCR valve pegged at 0 volts indicates that the SCR solenoid might be sticking. I made arrangements with George Collard to replace the valve. System shutdown about 1 hour after I spoke to George; he should be at the site today
	6/10/04	B240	Travel to Yosemite from Fresno P/P shut down June 08,04 change out SCR control valve (Glycol) machine air flow ratio not right, not getting enough air. Checked all air filters plug to send out snorkal filter. Replaced air filters at intake. Machine started then shut down after one hour. Return to Fresno from Yosemite
	6/14/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: I noticed that the system was running with a low S/C ratio, SCR valve pegged at 0 volts indicates that the SCR solenoid might be sticking. I made arrangements with George Collard to replace the valve. System shutdown about 1 hour after I spoke to George. No updates received; system has not called in to Plug Power since 6/8. System Status: Shutdown
	6/15/04		Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: I noticed that the system was running with a low S/C ratio, SCR valve pegged at 0 volts indicates that the SCR solenoid might be sticking, this was causing poor stack performance. I made arrangements with George Collard to replace the valve, system shutdown about 1 hour after I spoke to George. SCR valve was replaced and upon restart it shut down for O2/CH4 high. Snorkel filters were found to be very dirty, new filters shipped overnight to Mike Altemoos should arrive this morning.
	6/16/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: I noticed that the system was running with a low S/C ratio, SCR valve pegged at 0 volts indicates that the SCR solenoid might be sticking, this was causing poor stack performance. I made arrangements with George Collard to replace the valve, system shutdown about 1 hour after I spoke to George. SCR valve was replaced and upon restart it shut down for O2/CH4 high. Snorkel filters were found to be very dirty, new filters shipped overnight to Mike Altemoos should have arrived yesterday. Waiting for update from Michael.
M Altemoos	6/16/04	B240	Travel from Fresno to Yosemite Tried to start machine and had a cook off, shut down machine until plug power anilizes data. Travel to Fresno from Yosemite

M Altemoos	6/23/04	B240	Travel to Yosemite from Twentynine Palms Plug power identifies cuase of cook off may be gas leak. Changed out the Humidifier/ATO . Replaced snorkal filter, Checked for any leaks and updated LPG software, started P/P and had 02H2 High fault. Shut down P/P Plug to Travel to Twentynine Palms from Yosemite
	6/29/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: ATO/Hum can replaced, restarted on Friday and ran for about 15 minutes before shutting down for Gas/Air blower failure. No data is available at Plug Power. Mike Altemoos will be sending data from his laptop and should be on site tomorrow. COMSYS detected the following alarm: ALARM: Fuel Cell B240 Shutdown ALARM TIME: 6/26/2004 1:33:00 AM UTC EQUIPMENT: SITE: Yosemite Ranger Station
M Altemoos	6/29/04	B240	Travel to Yosemite From Twentynine Palms Changed out Gas Air Blower and Mot-11 Board, shipped without gaskets did not try to start machine. Gaskets leaking Gas and need to be replaced.
	6/30/04 6/30/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: ATO/Hum can replaced, restarted on Friday and ran for about 15 minutes before shutting down for Gas/Air blower failure. No data is available at Plug Power. Mike Altemoos will be sending data from his laptop and should be on site tomorrow. SARC board not holding memory, new board shipped to Cedar Lodge.
	7/1/04		Travel to Twentynine Palms From Yosemite

Engineer	Date	PP S/N	Summary/Milestones
	7/1/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: ATO/Hum can replaced, restarted on Friday and ran for about 15 minutes before shutting down for Gas/Air blower failure. No data is available at Plug Power. Mike Altemoos will be sending data from his laptop and should be on site tomo
	7/2/04		System Status: Shutdown Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: Gas/Air blower replaced, new gaskets needed for blower were shipped overnight and should arrive this morning.
M Altemoos	7/5/2004	B240	Travel to Yosemite from Twentynine Palms
	7/6/2004		System Status: SHUTDOWN Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage.
	7/6/2004		Replaced Gaskets for the Gas Air Blower and started the P/P. machine started with no problems.
	7/7/2004		Travel to San Diego from Yosemite
	7/7/2004		System Status: Running Incident Description: shutdown on 6/8 for Inverter Not Exporting AC after a short grid outage. Incident Resolution: Gas/Air blower was replaced, system is running. System was not calling in to Plug Power; I dialed the unit and it is running. Data logging was not set up so I configured it, it should call in tomorrow.
	7/8/2004		System Status: Running Incident Resolution: (7/7) System was not calling in to Plug Power; I dialed the unit and it is running. Data logging was not set up so I configured it, it should call in tomorrow. (7/8) system called in successfully this morning

LOGANEnergy Corp.

Site Report

Month October
Site 240 Yosemite
PP # 240

Engineer	Date	PP S/N	Summary/ Milestones	Mileage	Hours	Expenses	Items	Outage
George	**October 19, 2004**	**240**	**Travel from Sierra Army Depot to Yosemite**	**537**	**8**			
George	2004, 20 October	240	Trouble shoot shut down due to lack of water. Water was shut off by local boiler personell. Restarted fuel cell. Traveled to Fresno AB Parking via detours due to snow.	186	12			Fill Outage Report

LOGANEnergy Corp.		
Work Log Site Report		
Report Date	10/24/2004	
Site		
Power Plant Serial Number	240	
Engineer	George Raymond Collard	
Hours	4.00	
Mileage	720	
Event	Power plant shut down due to lack of water	

Incident Report		
Type of Outage	Scheduled	Scheduled or Unscheduled
Failure Date	10/22/2004	
Shutdown Time	16:00	
Restart Date	10/25/2004	
Restart Time	10:00	
Hours Unavailable	66.00	3 Days, 18 Hours, 0 Minutes.
Gas Meter Reading		
Electric Meter Reading		
BTU Meter Reading		
Fuel Cell Reading		
Describe Problem	Water was shut off to the R/O unit. The boiler maintenance personnel ad done some maintenance on the building heating boiler shutting off the make-up water to do so. When complete they forgot to turn the water	
Service/Corrective Action	Turned the water back on and restarted the machine.	

LOGANEnergy Corp.		
Work Log Site Report		
Report Date	1/13/2005	
Site		
Power Plant Serial Number	B240	
Engineer	Michael Altemoos	
Hours	26.00	
Mileage	1200	
Event	Shut down, batt low, modem not calling in and 12kw maitenance due.	

Incident Report		
Type of Outage	Unscheduled	Scheduled or Unscheduled
Failure Date	1/2/2005	
Shutdown Time	1:17 pm	
Restart Date	1/13/2005	
Restart Time	10:00 am	
Hours Unavailable	261.72	11 Days, 21 Hours, 43 Minutes.
Gas Meter Reading	0.00	
Electric Meter Reading	0.00	
BTU Meter Reading	0.00	
Fuel Cell Reading	0.00	
Describe Problem	SARC not saving data, modem not calling in, Batteries are low, 12kw hour maintenance due.	
Service/Corrective Action	replace SARC battery, charge all 12volt batteries, changed all filters and de-sulfur can, recieved retrofit kit for lpg	

LOGANEnergy Corp.	
Work Log Site Report	
Report Date	2/7/2005
Site	
Power Plant Serial Number	240
Engineer	George Raymond Collard
Hours	3.00
Mileage	464
Event	No BTU reading from CE box

Incident Report			
Type of Outage	Unscheduled	Scheduled or Unscheduled	
Failure Date			
Shutdown Time			
Restart Date			
Restart Time			
Hours Unavailable	0 Minutes		
Gas Meter Reading			
Electric Meter Reading			
BTU Meter Reading			
Fuel Cell Reading			
Describe Problem	Web site not getting BTU reading.		
Service/Corrective Action	Worked on getting pulse meter to work. Still does not work.		

LOGANEnergy Corp.	
Work Log Site Report	
Report Date	2/8/2005
Site	
Power Plant Serial Number	240
Engineer	George Raymond Collard
Hours	3.00
Mileage	16
Event	No BTU reading from CE Box

Incident Report			
Type of Outage	Unscheduled	Scheduled or Unscheduled	
Failure Date			
Shutdown Time			
Restart Date			
Restart Time			
Hours Unavailable	0 Minutes		
Gas Meter Reading			
Electric Meter Reading			
BTU Meter Reading			
Fuel Cell Reading			
Describe Problem	No BTU Reading on Web site		
Service/Corrective Action	Worked with Mark Ginther and got the pulse meter to work. Had to use a variable resister to make it work.		

LOGANEnergy Corp.							
Work Log Site Report							
Report Date	8/15/2005						
Site							
Power Plant Serial Number	B240 Yosemite Cerl						
Engineer	Michael Altemoos						
Hours	18.00						
Mileage	700						
Event							

Incident Report							
Type of Outage	Unscheduled			Scheduled or Unscheduled			
Failure Date	5/18/2005						
Shutdown Time	4:39 am						
Restart Date	5/31/2005						
Restart Time	4:23 pm						
Hours Unavailable	324.73	14 Days, 12 Hours, 44 Minutes.					
Gas Meter Reading	0.00						
Electric Meter Reading	0.00						
BTU Meter Reading	0.00						
Fuel Cell Reading	0.00						
Describe Problem	no data saved, filters dirty, struggles for air.						
Service/Corrective Action	changed out all filters, FS3, and SARC board, passed modem test, changed HEPA and replaced FS3 again, first						

LOGANEnergy Corp.							
Work Log Site Report							
Report Date	10/26/2005						
Site							
Power Plant Serial Number	B240						
Engineer	Michael Altemoos						
Hours	6.00						
Mileage	1200						
Event	maintenace call						

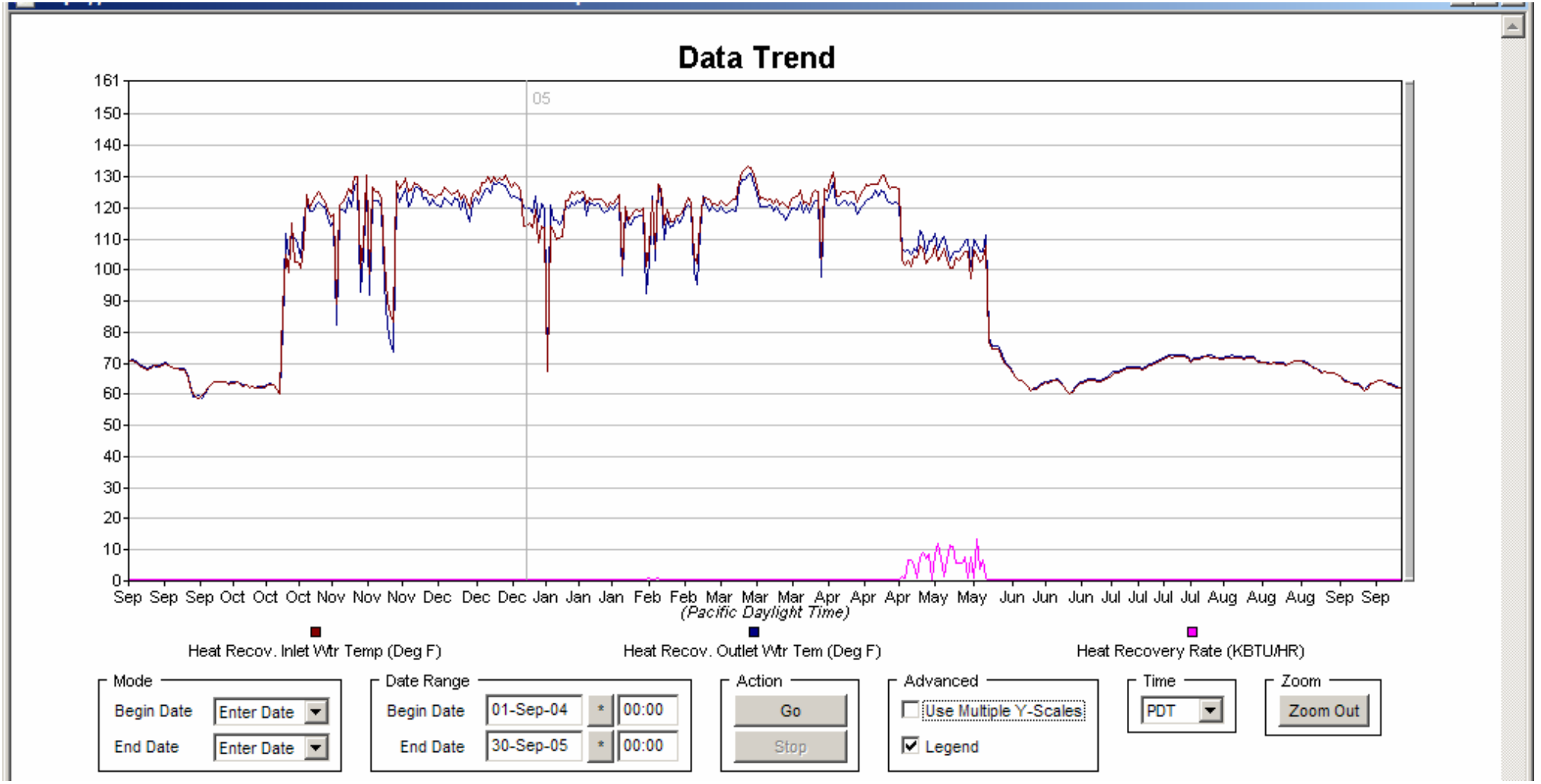
Incident Report							
Type of Outage	Unscheduled			Scheduled or Unscheduled			
Failure Date	10/21/2005						
Shutdown Time	5:29 pm						
Restart Date	10/22/2005						
Restart Time	9:00 am						
Hours Unavailable	16.52	16 Hours, 31 Minutes.					
Gas Meter Reading	0.00						
Electric Meter Reading	0.00						
BTU Meter Reading	0.00						
Fuel Cell Reading	0.00						
Describe Problem	machine not calling in, but running when I arrived. shut machine down and updated modem software, when I shut the machine down, it had trouble restarting, FS3 out of range and time out ATO heat up?						
Service/Corrective Action	changed all filters and FS3, finally worked it through the ATO heat up, machine running, HEPA can needs to be r						

2) Monthly Performance Data

System Number:	SU01B000000240-LPG			Commission Date:	38118				Site Location:	Yosemite National Park, California						
Site Name:	Yosemite			Fuel Cell Type:	Plug Power PEM											
Fuel Type:	LPG			Maintenance Contracto	LOGANEnergy Inc.											
Lower Heating Value:	943	BTU/scf		Local Residential Fuel Cost/Therm:		$/Therm			Local Base Fuel Cost/T	NA	$/Therm					
Capacity kW	5			Local Residential Elect	0.17	$/kWhr			Local Base Electricity C	NA	$/kWhr					
Month	Run Time	Month	Avail (%)	Energy Prod	Output Setl	Ave Output	Capacity Fa	Fuel Usage	Fuel Usage, LHV (BTUs)	Fuel Usage (SCF)	Elect Eff	Therm Rec	Therm Rec	Therm Eff	Overall Eff	
Mmonth	Op Hours	Hours	%	KwH	Set Point	kW	%	insert fuel consumption			%	BTU	Rate	%	%	
May-04	480	480	100.00%	1773.7	2.5	3.70	73.90%	7,098	24,218,376	23,942	25.00%		0	0	25.00%	
June-04	176	720	24.44%	431.4	2.5	2.45	11.98%	1,801	6,145,012	6,075	23.97%		0	0	23.97%	
July-04	610	744	81.99%	1525.6	2.5	2.50	41.01%	6,487	22,133,644	21,881	23.53%		0	0	23.53%	
Aug-04	744	744	100.00%	1866.6	2.5	2.51	50.18%	8,400	28,660,800	28,334	22.23%		0	0	22.23%	
Sep-04	700	720	97.22%	1750.5	2.5	2.50	48.63%	7,500	25,590,000	25,298	23.35%		0	0	23.35%	
Oct-04	695	744	93.41%	1561.5	2.5	2.25	41.98%	6,257	21,348,884	21,106	24.97%		0	0	24.97%	
Nov-04	672	720	93.33%	1628	2.5	2.42	45.22%	6,386	21,789,032	21,541	25.51%		0	0	25.51%	
Dec-04	702	744	94.35%	1743.3	2.5	2.48	46.86%	7,442	25,392,104	25,103	23.44%		0	0	23.44%	
Jan-05	439	744	59.01%	1096	2.5	2.50	29.46%	4,661	15,903,332	15,722	23.53%		0	0	23.53%	
Feb-05	672	672	100.00%	1661	2.5	2.47	49.43%	7,237	24,692,644	24,411	22.96%		0	0	22.96%	
Mar-05	744	744	100.00%	1793	2.5	2.41	48.20%	7,849	26,780,788	26,475	22.86%		0	0	22.86%	
Apr-05	621	720	86.25%	1509	2.5	2.43	41.92%	6,642	22,662,504	22,404	22.73%		0	0	22.73%	
May-05	216	744	29.03%	672.3	2.5	3.11	18.07%	812	2,770,544	2,739	82.84%		0	0	82.84%	
Jun-05	277	720	38.47%	670	2.5	2.42	18.61%	3,536	12,064,832	11,927	18.96%		0	0	18.96%	
Jul-05	310	744	41.67%	673.2	2.5	2.17	18.10%	4,097	13,978,964	13,820	16.44%		0	0	16.44%	
Aaug-05	480	744	64.52%	1088.7	2.5	2.27	29.27%	5,692	19,421,104	19,200	19.14%		0	0	19.14%	
Sept-05	603.76	720	83.86%	1509.4	2.5	2.50	41.93%	6,400	21,836,800	21,588	23.60%		0	0	23.60%	
Totals	9141.76	12168	0.751295	22953.2	2.5	2.510808	0.377272	98,297	335,389,364	331,566	23.36%	0	0	0	0.233645527	

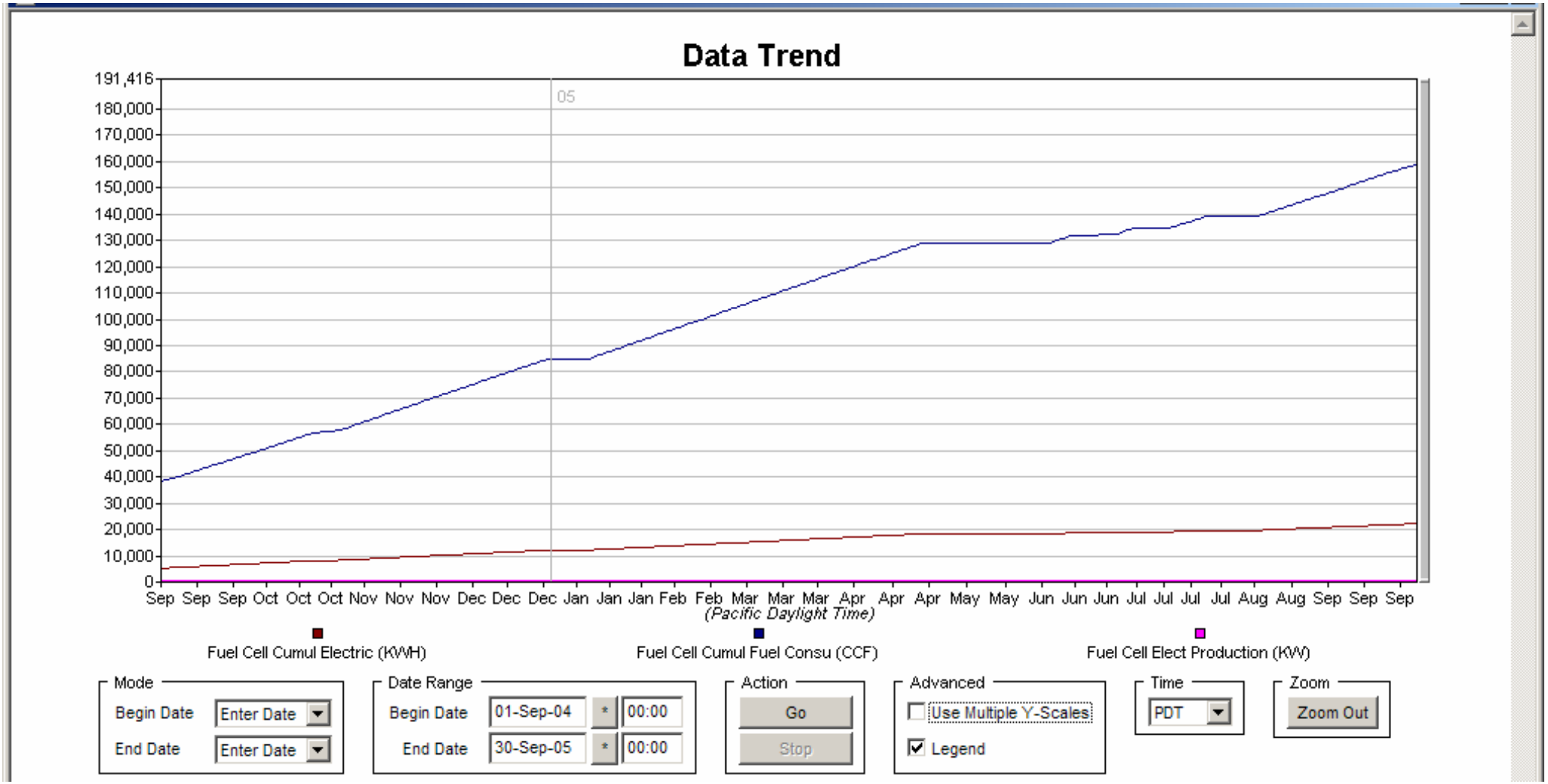
3. Performance Trend Analysis

The data plot indicates the poor performance of thermal recovery at this site between Sept 2004 and Sept 2005. The very low temperature delta between the fuel cell supply to boiler interface and the boiler return water in its heat loop accounts for the poor performance..



3. Continued, Performance Trend Analysis

The data plot indicates cumulative fuel consumption and cumulative electrical generation between Sept 2004 and Sept 2005.



3. Continued, Performance Trend Analysis

The plot compares power generation to electrical efficiency during the period Sept 2004-Sept 2005. The data during the period of September through December 2004 appears to be corrupted and overstated while the 2005 data tracks as it should.